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Poster paper

# Mechanical requirement and influence on the design and manufacturing of beam position monitor of Taiwan photon source

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The beam position monitors (BPMs) with submicron-level resolution act as the major eyes of storage ring in detecting the position of electron beams and are used for feedback system to guide the beam orbit to the desired track. Compared to major improvements on backend electronics, the physical devices generate and transmit signals had little improvement due to the lack of control on manufacturing processes including all mechanical tolerance requirements. The design started with ANSYS to simulate mechanical deformation. Due to the small size (submillimetre) and complicated assembly of feedthrough structure, it is difficult to achieve 1 % tolerance (submicron) in all aspects including machining and brazing. The smallest tolerance for machining is 5 μ and the overall tolerance will be 30 μm. The influence of the tolerance on mechanical will be shown on time-domain reflectometry measurement. The resulted heat-related issue will also be discussed and addressed since the problem happened at SLAC (private communication with Albert Sheng at Stanford Linear Accelerator Center) and DIAMOND (presented at the RF Button Heating Mini-Workshop at EPAC 2008). Manufacturing steps will be described. The consequence of mismatch on manufacturing will be discussed. All related measurement and simulation data are presented in this paper.

## 1. Mechanical requirement of beam position monitors

The main components of beam position monitors (BPM) are the four feedthroughs to detect the position of electron beam. When electron beam is running, the feedthroughs can become as hot as few hundred degree Celsius caused by trapped modes (Singh 2008). It is important to have rugged structure to avoid deformation and adequate heat conduction rate to avoid extreme heat accumulation on buttons.

Our first criterion of feedthrough design is to have 50 Ω characteristic impedance for the structure from connector to the interface before button due to the backend

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cable and electronics as 50 Ω. Otherwise, you will have a lot of reflected signals back into the feedthrough, which will generate unwanted heating. Thus, we have decided to use 7.2 mm diameter and 5 mm thick button based on the balance between vacuum chamber size, generated signal level and feedthrough impedance. The gap between button and wall is 0.3 mm to balance between mechanical control and the reduction of higher-order mode generation. The centre pin for actual signal transmission is 0.64 mm in diameter due to impedance matching with alumina ceramic used. With lower dielectric constant material, the centre pin could be larger and hence the better tolerance control. But their vacuum properties are not well known, and the essential heat conduction is much worse than ceramic. We have opted not to use low-dielectric-constant material in this project. The ceramic itself is 8 mm in diameter and 5 mm in thickness.

## 2. The ANSYS analysis on BPM flange temperature distribution and resulted deformation

The thermal analysis has been applied to this design and the results are shown in figure 1. It has been assumed that the air side (top) of the BPM flange has fixed temperature at 25°C with adequate heat dissipation by ambient air. A constant 3 W power has been applied to the button. The highest temperature is 127°C at the button surface. The largest deformation occurred at the button and the size is less than 9 μ. If, in reality, the measured temperature on the flange is higher (e.g. 35°C), the temperature difference will be added up to the 127 °C (e.g. 137 °C).

## 3. The influence of chamfer on ceramic

The first version of feedthrough includes chamfers on both sides. This resulted in the two reflection peaks on the time-domain reflectometry (TDR) test as shown in figure 2. The second version reserves chamfers only on one side for brazing purpose. The production of second version is ongoing.

## 4. Discussion

The BPM feedthroughs are installed on vacuum system. There is a balance between the impedance it adds on the whole storage ring, the compatibility of the material it used on vacuum side for ultra-high vacuum system, the power it

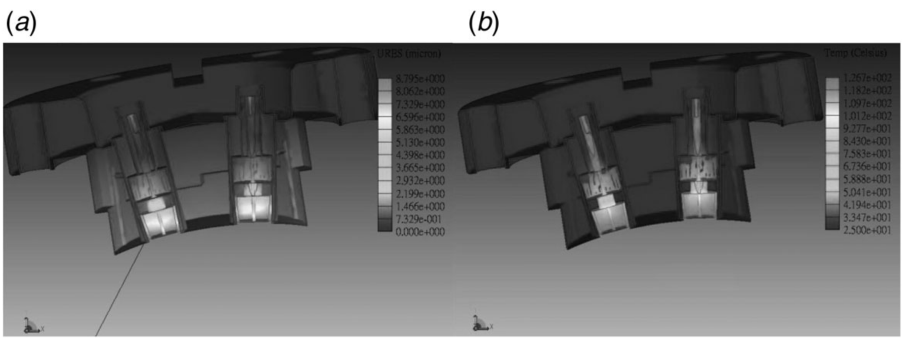


FIGURE 1. (*a*) Deformation analysis at 3 W absorbed power. (*b*) Temperature analysis.

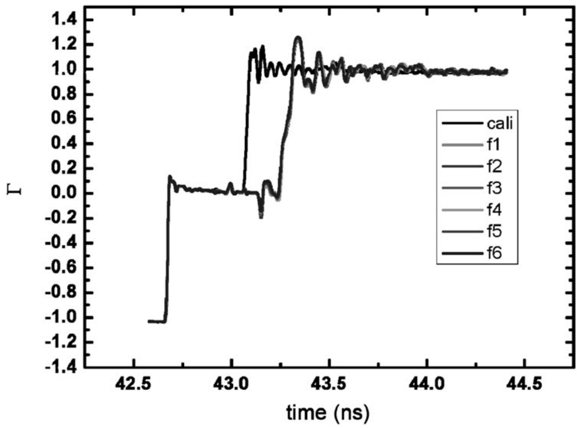


FIGURE 2. TDR measurement on first-version feedthrough. Γ on the vertical axis is the reflection coefficient (−1 means short and 1 means open). The black line (cali) is measured without feedthrough. All six feedthrough measured results (f1–f6) are well duplicated and difficult to distinguish on this plot.

absorbed due to trapped modes and the power it transmits to signal-processing electronics. From the above calculation, manufacturing and measurement experience, we have decided to use ceramic as the insulation material, Kovar as the centre pin and outer wall material, and SUS 316L as flange and button material. Ceramic has substantially higher thermal conductivity than glass and is more compatible with ultra-high vacuum in terms of outgassing issues. The only benefit of glass is its lower dielectric constant. Until we have further confirmation on the outgassing characteristics of new material, we will stick to most commonly used material.

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